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Longrun Competitiveness of Australian Agriculture

Jerry Sharples and Nick Milham

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Longrun Competitiveness of Australian Agriculture. By Jerry Sharples and Nick Milham, Economic Research Service, U.S. Department of Agriculture, Foreign Agricultural Economic Report No. 243.

Abstract

This report identifies domestic factors that made Australian agriculture competitive since the 1950s and those most likely to determine its future competitiveness in global markets. The agricultural export volume of Australia, one of the world's major exporters of agricultural products, more than doubled between the mid-1950s and mid-1980s due to expanded public and private investment in agriculture and improved production and marketing efficiency. Investment and efficiency, influenced by changes in Government policy, likely will be key factors shaping the future of Australian agriculture.

Keywords: Australia, agriculture, agricultural exports, competitiveness, supply, government policy, technology.

Note: All monetary values in this report are expressed in Australian dollars.

Cover photo: Courtesy Australian Foreign Affairs and Trade Department.

The Authors

Jerry Sharples, an agricultural economist with the Economic Research Service, U.S. Department of Agriculture, conducted research on Australian agriculture at the Australian Bureau of Agricultural and Resource Economics as part of a professional exchange program between the United States and Australia. Nick Milham, an agricultural economist who was with the Australian Bureau of Agricultural and Resource Economics when this report was prepared, worked with Sharples on the project.

Washington, DC 20005-4788 December 1990

Foreword

This report is a result of the 1987-88 professional exchange program between the Australian Bureau of Agricultural and Resource Economics (ABARE) and the Economic Research Service (ERS) of the U.S. Department of Agriculture (USDA). Jerry Sharples, from ERS, was posted to ABARE from August 1987 to July 1988, and Brian Johnston, from ABARE, was posted to ERS from January to December 1988. The project examined the longrun competitiveness of U.S. and Australian agriculture in world markets. This report focuses on Australian agriculture. A companion report, written by Brian Johnston and to be published later, focuses on U.S. agriculture.

Nick Milham, an agricultural economist with ABARE at the time this report was prepared in 1988, worked with Jerry Sharples on the project.

Many people provided ideas and data and reviewed various drafts. We would like to thank the many employees of ABARE who contributed. Brian Johnston, a co-planner of the research project, gave valuable assistance in the early stages and reviewed drafts. Onko Kingma provided stimulation and support throughout the project and gave earlier report drafts indepth reviews. Alistair Watson, then chief research economist for ABARE, shared his broad knowledge of the history and literature of agriculture and provided contacts with other agriculturalists. Thanks also go to Nico Klijn and Ian Dalziell from ABARE and Roger Mauldon from the Industries Assistance Commission of the Australian Commonwealth Government for their reviews and comments. We are grateful to Larry Deaton and William Coyle, of ERS, who provided helpful comments. We thank Carol Stillwagon and Renata Penn, ERS, who prepared the graphics. We appreciate the editorial contributions of Enid Hodes, Economics Management Staff of USDA.

Contents

Summary

Domestic factors that made Australian agriculture competitive since the 1950s and those most likely to determine its future competitiveness in global markets are discussed in this report. Australia, one of the world's major exporters of agricultural products, more than doubled its agricultural exports between the mid-1950s and mid-1980s. Its future agricultural prosperity depends on its ability to sustain competitiveness in export markets.

The competitiveness of Australia's agricultural sector between the 1950s and mid-1980s stemmed from increases in production and marketing efficiency and large growth in agricultural investment. Farm output during that period grew faster than domestic consumption even though the size of the farm labor force and world commodity prices declined. Key factors that will shape its agricultural future will be efficiency and investment, influenced by changes in Government policy.

The main forces behind growth in Australian agricultural production since the 1950s were a large flow of new Government-sponsored production and marketing technology, improved farming skills, and an economic climate that provided incentives for investment in agriculture.

Future farm export competitiveness also will be closely linked to improvements in production and marketing efficiency and the size of agriculture's capital stock. Government policy will have a big influence on whether there will be incentives for expanded investment in farming and whether agricultural productivity will continue to improve.

Four Government policy issues likely will play important roles in shaping agriculture. The first is the level of Government funding of agricultural research and education to improve the agricultural work force's technical and management skills. Public investment appears to be highly important in improving the efficiency of Australia's agriculture.

The second is the level of public assistance (subsidy) to agriculture and to the rest of the economy. Agriculture would be more competitive in world markets if Australia reduced assistance to all its economic sectors.

The third is reform of publicly sanctioned rules governing export marketing of farm products. Research suggests that per-unit costs of moving commodities, such as wheat, from the farm to shipboard could be lowered substantially.

The fourth is balancing farmer interests in short-term profits and the national interest in maintaining land and water quality. Policymakers will be pressured to tighten controls on resource degradation. Little is known, however, about the relationship between farming and natural resource degradation.

Australia

Indian Ocean
Pacific Ocean
Northern Territory
Queensland
Western Australia
South Australia
New South Wales
Brisbane
Murray-Darling Basin
Perth
Adelaide
Victoria
Sydney
Canberra
Snowy Mountains Project
Melbourne
Tasmania

Longrun Competitiveness of Australian Agriculture

Jerry Sharples
Nick Milham

Introduction

Australia is one of the world's major exporters of agricultural products. It accounts for over one-half of the world's wool exports, about one-fourth of the world's beef exports, and nearly one-seventh of the world's wheat exports. Two obvious reasons for Australia's competitiveness in world agricultural markets are its large agricultural resource base and its small population. But Australia's agricultural development is not that simple. From the 1930s to the early 1950s, exports were stagnant because production expanded only enough to keep pace with its growing population. From the 1950s on, however, exports grew at an impressive rate, even though world commodity prices fell.

This report examines why Australian exports grew in the past with a view to better understanding Australia's present and to preparing for the future. We focus on the main domestic forces shaping the longrun export competitiveness of Australian agriculture (world market forces are not covered). We do so by applying principles of competitiveness to Australia's agriculture for the period between the mid-1950s and the mid-1980s. Once identified and crudely quantified, these domestic forces are used to draw implications for the future competitiveness of Australian agriculture.

Popular perceptions in Australia of agriculture's future role in the overall economy seem to be shaped by the immediate health of the sector. In the mid-1980s, it was popular opinion that Australia needed to be less dependent on agriculture because agriculture's earnings were so volatile and were falling. At that time, the longrun outlook for export sales was not encouraging and the perception was that the economy needed to diversify more. Some in Australia argued that the Government needed to shift its research and development support away from agriculture and toward expanding other newer "high technology" industries. By mid-1988, however, popular disfavor with agriculture seemed to have diminished as export earnings once again expanded. The perception that the rural sector was important to the future of the Australian economy was growing once again. We attempt in this report to step back from shortrun ups and downs in agriculture and focus on longrun forces shaping Australian agriculture.

A discussion of the economic concept of competitiveness lays a foundation, and then a simple model of the agricultural sector is used throughout the rest of the report to help analyze agriculture since the 1950s. We then consider the future. The approach used is mainly descriptive rather than quantitative. This report provides a framework for further analysis.

The Theory of Competitiveness[1]

To evaluate agriculture's competitiveness in domestic resource markets and international commodity markets, competitiveness must be defined. Freebairn (1986, p. 2) provides a useful definition. He says that being competitive is the:

> ... ability to deliver goods and services at the time, place and form sought by overseas buyers at prices as good as or better than those of other potential suppliers whilst earning at least opportunity cost returns on resources employed.

This definition points out two types of competition. First, the agricultural sector competes in the international market to "deliver goods and services ... at prices as good as or better than those of other potential suppliers." Second, the agricultural sector competes in domestic factor markets by having to earn "at least opportunity cost returns on resources employed." If the sector cannot at least earn opportunity costs (for example, pay current wage rates for labor or at least earn the current rate of interest on investment), then these resources will not be invested in the agricultural sector. Resources in agriculture that do not at least earn their opportunity cost will eventually be withdrawn. The land resource, however, is a special case. Most agricultural land has no use apart from agriculture, so its opportunity cost to agriculture is near zero. Marginal land

[1]An excellent discussion of the concepts, measurement, and policy of competitiveness (applied to U.S. manufacturing) is found in Scott and Lodge (1984). For recent comments about the competitiveness of U.S. agriculture, see U.S. Department of Agriculture (1987), White (1987), and Barkema, Drabenstott, and Tweeten (1990). (Last name of author(s) and date of publication in parentheses refer to items cited in References at the end of this report.)

will continue to be used in agriculture as long as it yields a positive return.

This report examines competitiveness in relation to longer run basic economic forces shaping Australian agriculture. This approach emphasizes changes over decades and ignores month-to-month shocks to the economy that temporarily increase or decrease production and exports.

A Model of Agricultural Competitiveness

Agricultural competitiveness can be studied at various levels: the level of the economy, sector, industry, or firm. Our analysis focuses on competitiveness at the sector level. To do this, we used some simplifying assumptions. First, we assumed that all of the commodities produced in agriculture can be aggregated into one output. This approach requires that movements over time in the price and volume of the aggregate output be accurately represented by index numbers. Using that assumption, we show the main forces shaping the agricultural sector's competitiveness in figure 1.

In the "domestic market" portion of figure 1, S_F represents the supply curve for total agriculture where all commodity output is assumed to be represented as one aggregate product and D_F represents the domestic demand curve for agricultural output priced at the farm gate. In the "world market" portion of figure 1, ES_F represents the export supply curve measured at the farm gate. It represents the portion of production that is available for export after all domestic needs are met, and is the horizontal difference between S_F and D_F. The export supply curve measured at the port is ES_P. The difference between ES_P (exports priced at the port) and ES_F (exports priced at the farm gate) represents the cost of storage, handling, and other marketing services. Thus, the farm-gate price, P_f, is equal to the export price, P_p, minus the costs of marketing services. At price P_f, quantity Q_d will be produced, Q_f will go to domestic uses, and Q_x (Q_d - Q_f) will be exported.

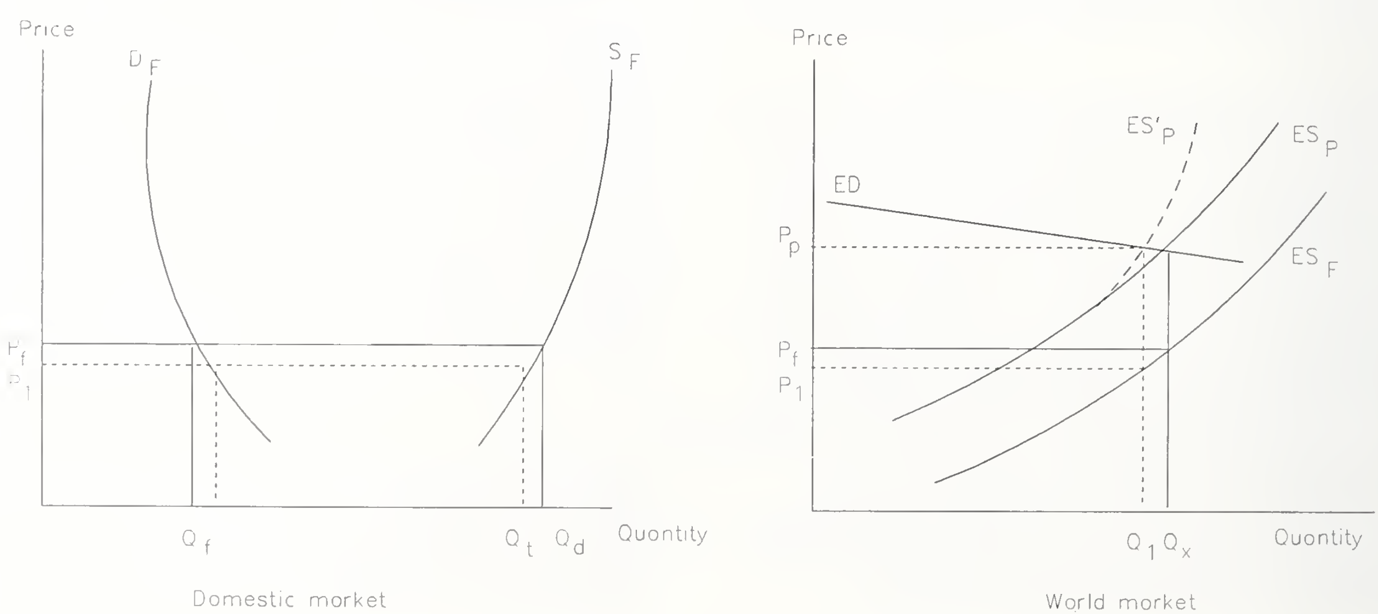
Australian agriculture's competitiveness in world markets is shown by the location of the export supply curve ES_P. That curve represents the variable cost of exporting the marginal (last) unit. The marginal export unit at Q_x, in the right-hand panel of figure 1, is produced, processed, and transported to Australia's border at a total variable cost equal to P_p. Export units to the left of Q_x in figure 1 cost less to deliver to the border. Australia, in this case, would be competitive at world price P_p in exporting any quantity up to Q_X, because that quantity could be sold "... at prices as good or better than those of other potential suppliers whilst earning at least opportunity cost returns on resources employed" (Freebairn, 1986).

Useful concepts of competitiveness can be derived from figure 1. Forces determining Australia's agricultural exports can be analyzed in two components:

- The export supply curve, ES_P, which is shaped by forces within Australia; and
- The export demand curve, ED, which is determined by forces outside Australia.

This report focuses on the first component, the export supply curve. Shifts in that curve summarize the forces within Australia's control that determine the competitiveness of its agriculture. From Australia's point of view, any force that shifts the export supply curve right can be said to make agriculture more competitive. Improved agricultural competitiveness comes about by reducing costs of market-

Figure 1
An abstract view of the domestic and world markets for Australian agricultural products



ing services, by shifting the total supply curve right (that is, by all the ways of reducing the variable costs of production), or by decreasing domestic demand. Opposite forces would decrease Australia's agricultural export potential and decrease its competitiveness in international agricultural markets.

Limitations of the Model

Keeping an economic model as simple as possible has obvious advantages for performing economic analyses and communicating results. The associated simplifying assumptions, however, tend to widen the gap between the model and reality. We therefore examine the key assumptions used in our model.

Aggregation Bias

We assume that the total output, domestic use, and exports of agriculture can be represented accurately by index numbers. Agricultural output includes such diverse products as wool and wine. An aggregate price index is also assumed to accurately represent the movement of all agricultural output prices over time. It is possible that these indexes could contain considerable bias. If the portion of each commodity in the aggregate mix stays the same over the three decades examined in this report, then an index number could accurately represent changes in the aggregate quantity of that mix. If there are major changes in the mix of commodities, the potential for bias increases. The mix of the major commodities produced and traded shows no substantial longrun change, and the output prices tend to move up and down together over the longer run. Thus, it appears that the benefits of aggregation outweigh the costs.

Partial Equilibrium

The simple model in figure 1 is partial equilibrium (containing only the agricultural sector) rather than general equilibrium (containing agriculture as an integral part of the total economy). The simpler partial equilibrium analysis can incorporate the analysis of effects of events in nonagricultural sectors of the economy on agriculture. However, it cannot trace the effect of an event that occurs in agriculture through the nonagricultural sector and back to agriculture. For example, increased agricultural output might increase the demand for labor, raise wages in the whole economy, and consequently raise wages in the agricultural sector. We assume, for the partial equilibrium model used here, that wages would not change, whereas a more general equilibrium model could incorporate the wage increase and trace its effect back to agriculture.

For our purposes, agriculture can be represented by a partial equilibrium model, because it uses only a small share of Australia's nonland resources and generates only about 4 percent of the country's income (Australian Bureau of Statistics, 1988a). Significant changes in agricultural output thus will have only a small effect on the demand for inputs in the rest of the economy. The simple partial equilibrium analysis used in this report should yield nearly the same results as would a more thorough general equilibrium analysis. The one exception to this generalization is that agriculture accounts for about one-third of all export earnings. The partial equilibrium analysis will miss the effect that a large change in agricultural exports will have on the trade balance and exchange rates (and thus on agricultural prices). This linkage is discussed in more depth in a later section.

Value-Added Processes

The gap between the value of agricultural exports at the port and their value at the farm gate consists of (a) handling and transport and (b) value-added processes. The latter changes the form of the product (for example, changing grapes into wine). The former does not. The gap between ES_P and ES_F in figure 1 (world market) includes transport and handling costs, but it does not adequately capture value-added processes. In the wine example, the export product is changed considerably from the farm product, violating an assumption of this partial equilibrium model. However, this is not a major problem for the analysis because most of Australia's agricultural exports are in bulk form and most of the difference between farm value and export value is the cost of handling and transporting bulk commodities.

Social Costs and Distortions

The simple model presented here represents the functioning of private profit-maximizing agents in the market. The supply curve in figure 1, for example, includes only private costs producers face. It does not include any additional costs due to differences between private and social opportunity costs of resource use. An example is the cost to nonfarmers associated with a farmer's use of a chemical that pollutes the water supply. The supply curve does, however, include input cost distortions and product price distortions producers face due to taxes, subsidies, and other public policies. These distortions are also discussed later in the report.

Linkages to the Rest of the Economy

Nonagricultural forces affect the export supply curve, ES_P in figure 1, and these forces thereby affect agriculture's competitiveness. The agricultural sector, as represented in figure 1, is linked to the rest of the economy in three main ways.

First, food and fiber compete for the consumer's dollar against other goods and services. Changes in consumer income, tastes, or prices of other goods will affect the domestic demand for agricultural products and shift the demand curve, D_F.

Second, agricultural production and marketing processes use resources in competition with other sectors of the economy. Changes among other sectors in the demand for

these resources will affect resource prices and shift the supply curve, S_F.

Third, changes in macroeconomic forces can lead to changes in the value of the Australian dollar relative to other currencies. For example, a drop in the value of the Australian dollar increases the price in Australian dollars that Australian exporters receive. This effect could be represented in figure 1 by a shift up in the export demand curve, ED. The fall in the value of the Australian dollar will also raise the domestic price of imported goods, including production and marketing inputs. This, by itself, would shift the supply and export supply curves to the left in the short run. (This effect is not shown). The former effect on producer returns would be expected to exceed the latter because not all inputs would be affected by the price increase. If the devaluation were expected to continue, profit expectations would improve and additional resources would be invested in agriculture. The net effect over the longer run would be for the supply and export supply curves to shift to the right. A devaluation of the Australian dollar would be expected to make agriculture more competitive in international markets.

Performance of Australian Agriculture Since the Early 1950s

We examine the production and export performance of Australian agriculture since the early 1950s using the conceptual framework of competitiveness. Growth in agricultural exports and shifts in export supply curves are examined first. Then, the main domestic forces affecting export growth are examined, including growth in production, shifts in supply curves, improvements in export marketing, growth in domestic demand for agricultural products, and changing macroeconomic forces.

Agricultural Export Trends

Australian agriculture has an impressive record of increasing export volume since the early 1950s. This trend sharply contrasts with earlier years. There was a long period of stagnant exports through the Great Depression years and World War II. By the early 1950s, export volume was no higher than in the early 1930s. But then a long period of rapid growth began that continued through the mid-1980s (fig. 2). However, as export volume increased, the year-to-year volatility also increased, with major peaks in 1972 and 1980 and troughs in the mid-1970s and early 1980s.

The index of export prices received by Australian farmers fell from 1953 to 1987 by 57 percent in real terms, falling most sharply before the early 1970s. Since then, this long-term downward trend has been overshadowed by short-term price fluctuations (fig. 3). There would have been a greater downward trend in commodity prices since the mid-1970s had it not been for the marked decline in the value of the Australian dollar.

There is a strong link between the export price movements and world events. The 1950s and 1960s were years of stability in the world economy, with low inflation rates and high levels of growth in the main trading nations (Harris, 1982; Gunasekera, Parsons, and Kirby, 1987). This period also saw large gains in agricultural productivity in many countries. As production returned to and surpassed prewar levels and the volume of agricultural trade increased, export

Figure 2
Australian agricultural export volume, 1930-87

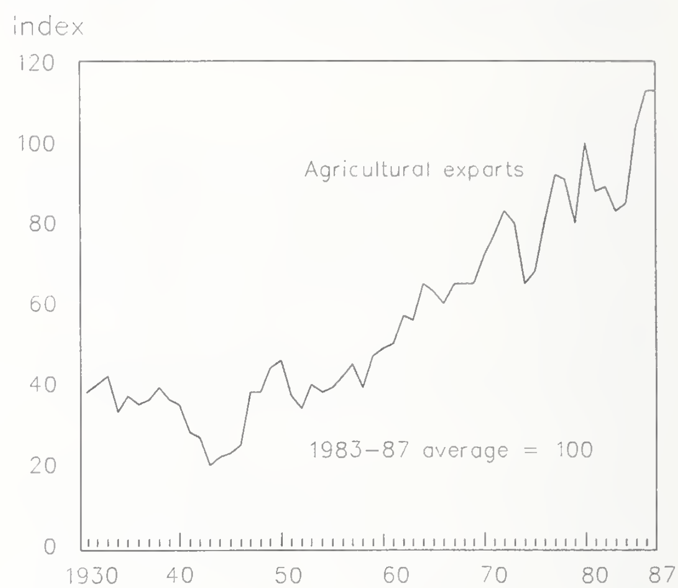
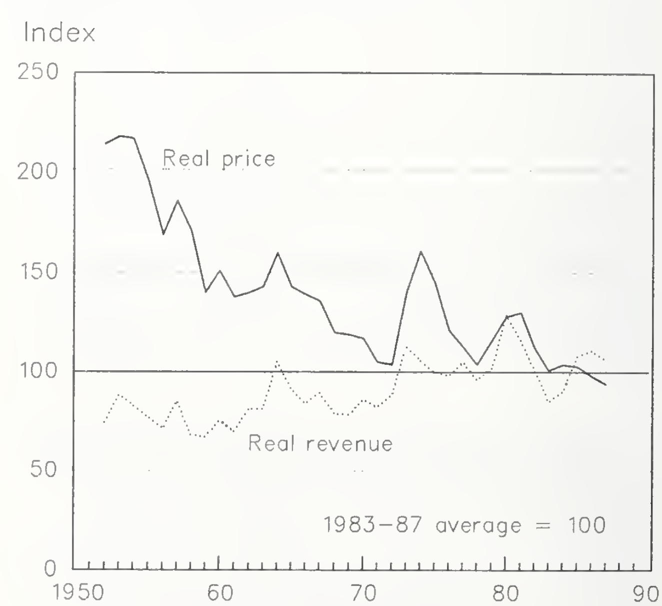


Figure 3
Real price and real revenue of Australian agricultural exports, 1952-87



prices trended downward. The recovery in world grain prices in the early 1970s was sparked by poor seasonal conditions in wheat- and rice-producing countries and the Soviet Union's emergence as a large wheat purchaser. This recovery was accentuated by the 1973 oil price shock, which encouraged a further resurgence in the prices of food and natural fibers (Stoeckel and Miller, 1982).

The United Kingdom joined the European Community (EC) in 1973 and adopted the EC's trade barriers. This event greatly reduced Australian exports to the United Kingdom, its traditional trading partner. Although agricultural export volume fell over the next 2 years, it recovered rapidly and regained longrun growth potential. The United Kingdom was replaced by other trading partners in North America and then Asia, whose markets for Australian exports had expanded.

The middle and late 1970s saw global agricultural output increase faster than import demand, because of productivity gains and agricultural protectionist policies in many industrialized nations. As food stocks grew and the world economy recovered from the oil price shock, export prices eased. In Australia, this situation coincided with a period of very high inflation (averaging 13 percent per year in the mid-1970s), and real export prices slumped to a record low in 1978. A second oil price shock in 1979 and increased import demand from oil-exporting countries and centrally planned economies stimulated a short-term recovery around the turn of the decade. The world entered an economic recession in the early 1980s, and once again trade prices declined to record-low levels as global import demand fell behind production.

As a result of these real price and volume movements, the real value of total agricultural exports showed only a small upward trend but great volatility since the 1950s (see fig. 3).

Although the volatility of export prices was caused mainly by overseas forces, the major explanation for the long-term growth and shortrun volatility of export volume can be traced to domestic production. Beginning in the 1950s, agricultural production grew faster than domestic demand. Reporting on the period 1950 to 1975, Shaw (1982, p. 19) wrote:

> ... production rose thanks largely to technological progress, pasture improvement, the greater use of more effective fertilizers, fodder conservation, mechanization—with bulk handling of grain, and aerial top-dressing, the increased use of pesticides and the destruction of the rabbit by myxomatosis. As a result, despite the inevitable seasonal fluctuations, the volume of farm production increased between 3 and 4 per cent annually.

Agricultural output rose by an annual average of 3.2 percent over the last four decades (fig. 4). The major deviations from the growth trend were between 1979-80 and 1982-83 and were the result of severe drought in the eastern States of Australia. Earlier droughts between 1969-70 and 1972-73 also caused production to level off.

Shifts in Export Supply Curves

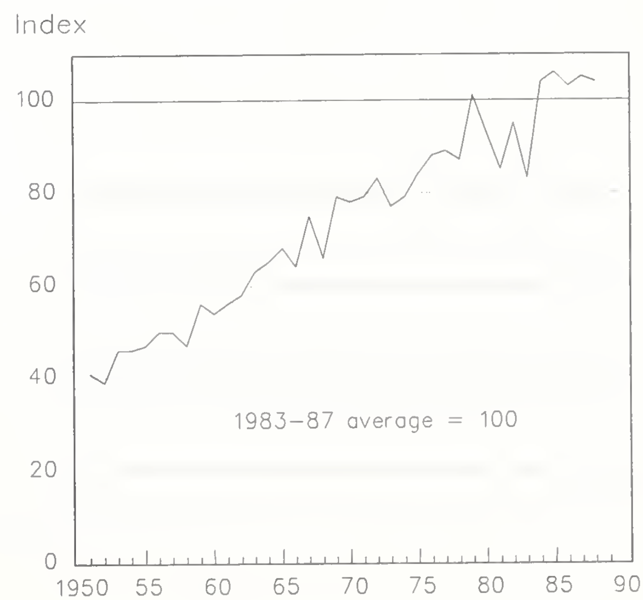
Export prices and quantities must be expressed in terms of export supply curves to relate the export performance shown in figure 2 to the concept of competitiveness used in this report. Figure 5 shows these relationships. Five export supply curves of Australian agriculture are shown, one for each decade from the 1950s to the 1990s. The supply curves represent the relationship between agricultural export prices and quantities for four selected past periods and for one future period.

Each curve in figure 5 represents a 5-year period, with "1950s" representing financial years 1952-53 to 1956-57, "1960s" representing financial years 1962-63 to 1966-67, "1970s" representing financial years 1972-73 to 1976-77, and "1980s" representing financial years 1982-83 to 1986-87.[2] A 5-year average is used so that each curve approximates average market conditions, reducing the effect of year-to-year volatility of prices and quantities.

The shape and location of each curve is derived using historic price and quantity data, results from other research, and assumptions about agricultural exports (see the appendix for estimation procedure). Point A on each curve of figure 5 represents the indexes of observed average annual export prices and quantities for the given 5-year period (data are presented in table 1). Other points along the

[2]Australian agricultural statistics are reported for the financial year beginning July 1. Thus, "1952-53" means July 1, 1952 to June 30, 1953.

Figure 4
Australian agricultural production volume, 1950-88

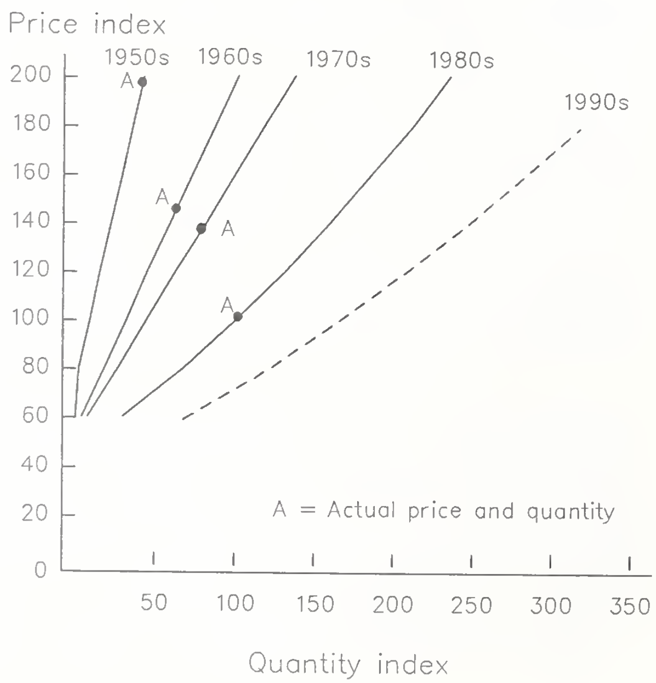


curves represent the expected export volumes that would have occurred in those years at other export prices. For example, the average export price index and average export quantity index were 100 (by definition of the index base period) for the export supply curve representing 1982-83 to 1986-87. Suppose producers and domestic consumers of agricultural products had expected the export price index to be 120 rather than 100 during that 5-year period. The 1980s export supply curve indicates that export volume would have been about 130, or 30 percent higher than the actual volume. The higher export prices would have encouraged additional production and discouraged domestic consumption, leading to more exports.

The export supply curve for agriculture shifted to the right each decade after the mid-1950s (see fig. 5). According to our definition of competitiveness, this shift is evidence that the net effect of all the domestic forces affecting agriculture since the mid-1950s was to make agriculture more competitive in export markets. Consequently, export volume increased even though real export prices continued to decrease. Agricultural exports increased by 144 percent between the mid-1950s and the mid-1980s even though real export prices dropped by 49 percent. If there had been no shift in export supply, agricultural exports would have declined rather than expanded after the mid-1950s.

The shift in the agricultural export supply curve since the 1950s is evidence that Australia's agricultural supply grew faster than domestic demand. We look next at the major forces behind the shifts in agricultural supply and demand since the 1950s.

Figure 5
Export supply curves of Australian agriculture, 1950-90



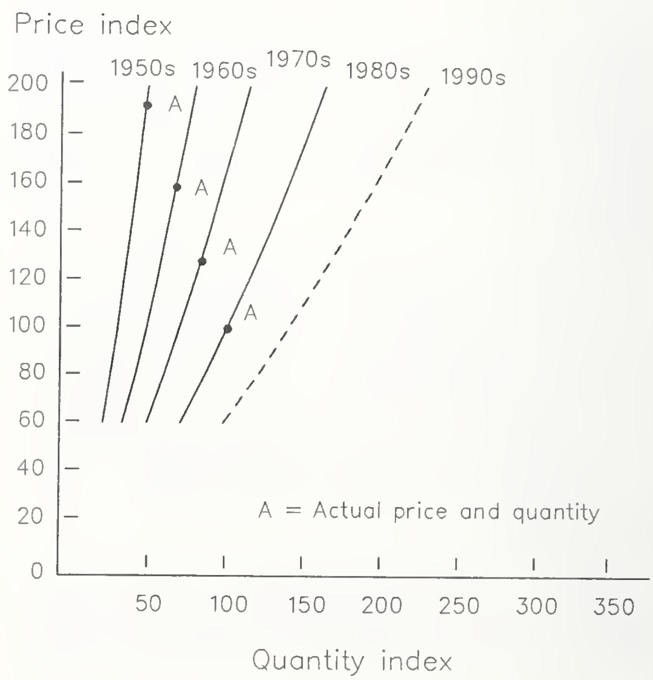
Agricultural Supply Curves

To interpret forces shaping agricultural production, we constructed supply curves for the aggregate of all Australian agricultural production (fig. 6) using the same approach as used for the export supply curves. The four past supply curves represent the same periods as in figure 5; the projected curve, represented by a dashed line, will be discussed later in the report. Point A on each supply curve shows the annual average indexes of observed farm-gate prices and quantities produced during the specified 5-year period. Table 1 presents the data for these points.

Points along each supply curve represent estimates of aggregate production that would occur in response to changes in the average expected price index at the farm gate over the 5-year period. Those changes would come about because of shifts in producers' resource use. For example, if producers had expected the real price index to exceed 100 in the mid-1980s, they would have used more marginal land, more hired and family labor, and more cash inputs than they actually did. Some additional investment would have been made to improve pasture, and livestock herds would have been somewhat larger.

A summary of recent studies indicates considerable disagreement about the appropriate slope of the supply curve; that is, the responsiveness of total agricultural output to changes in the overall level of farm commodity prices (see appendix). We assumed that over a 5-year period production would increase 7 percent in response to a 10-percent increase in expected prices. The same supply response is assumed for each of the four supply curves in figure 6.

Figure 6
Production supply curves of Australian agriculture, 1950-90



A shift to the right in the supply curve represents an expansion in the agricultural sector's production potential. It measures adjustments over the long run. Production potential can be increased by (a) increasing efficiency (more output per unit of input) or (b) increasing the size of the agricultural production plant (using more and higher quality primary resource inputs). Conceptually, this production potential responds to longer run forces and would not be observed within a 5-year period.

The points labeled "A" on each curve in figure 6 represent the observed price and quantity indexes. Going from point A on the 1950s curve to point A on the 1980s curve shows the combined effect of (a) moving down the supply curve (due to the falling real price index) and (b) shifting the supply curve right (due to the expansion of production potential). The effect of longrun expansion of agriculture's production potential since the 1950s exceeded the effect of the fall in prices. Consequently, output more than doubled.

One way to measure the expansion of agriculture's production potential is to observe the implied increase in production over time at a constant real price index. This is equivalent to measuring the shift in the supply curve along the quantity axis. The supply curve shifted right an average of about 4 percent a year between the mid-1950s and the mid-1980s. As mentioned earlier, this increase in production potential measures the combined effect of using more

Table 1—Measures of inputs and outputs in Australian agriculture, four selected periods from 1952-53 to 1986-87[1]

Item	1952-53 to 1956-57[2]	1962-63 to 1966-67[2]	1972-73 to 1976-77[2]	1982-83 to 1986-87[2]
		Index (1982-83 to 1986-87 = 100)		
Export volume	41	62	78	100
Export price (real)	197	144	136	100
Export revenue (real)	81	90	105	100
Production volume	47	67	83	100
Production price (real)	192	158	127	100
Gross domestic product from agriculture (real)	105	114	117	100
Labor input:				
Total rural employment	124	110	99	100
Hired labor volume	NA	129	105	100
Hired labor wage (real)	75	80	97	100
Capital input (real value): [3]				
Livestock	70	84	127	100
Plant and equipment	51	72	84	100
Land improvements	43	69	105	100
Total nonland	48	71	103	100
Land	50	69	91	100
Cash input:				
Volume	8	21	41	100
Price (real)	88	94	93	100
Cattle inventory	70	81	138	100
Sheep inventory	91	111	98	100
Area in farms	92	99	102	100
Sown area	40	67	88	100
Value of Australian dollar[4]	140	140	154	100
		Percent		
Interest rate (real)	.5	2.6	-3.3	5.5

NA = Not available.

[1]Prices, price indexes, revenues, and capital values are deflated by the Consumer Price Index (CPI) (Australian Bureau of Statistics, 1988b).

[2]Financial years starting July 1.

[3]See text for definitions of capital categories.

[4]Trade weighted index.

Sources: Interest rate, Reserve Bank of Australia (1987); capital investment, Powell and Milham (1990); all other, Australian Bureau of Agricultural and Resource Economics (1987a).

and improved farm inputs and achieving improved efficiency from those inputs.

Sources of Shifts in the Supply Curve

Four categories of inputs (capital, land, labor, and cash inputs) and productivity growth are examined in detail to explain the sources of the output expansion. In the following discussion, capital, land, and labor are alternatively referred to as primary inputs to production.

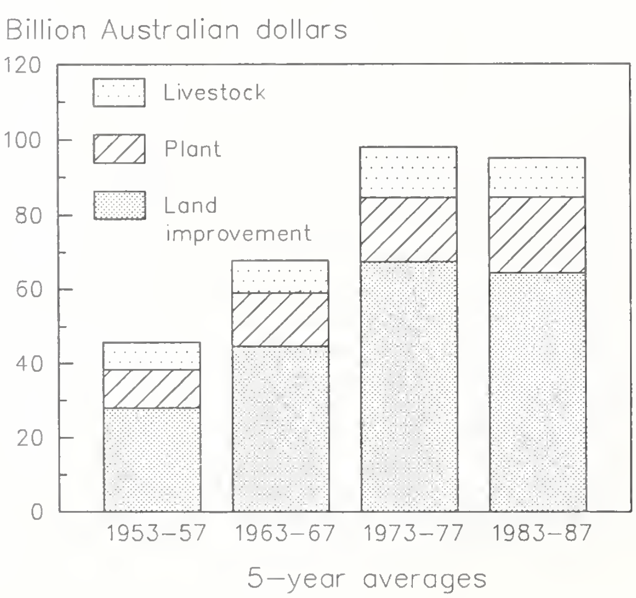
Capital

Growth of the capital stock was a major shifter of agriculture's supply curve in the past. Annual agricultural investment exceeded depreciation, the capital stock grew, output potential grew, and the supply curve shifted right.

Details of the growth of the capital stock can be shown by using Australian definitions of the components of capital. Powell (1974, 1982) and Powell and Milham (1990) divide agriculture's capital stock into four categories. They are land (unimproved land plus public investment in rural roads, irrigation systems, and other land-related infrastructure); land improvements (value added to land due to clearing, pasture improvement, fences, water supply, and structures); plant and machinery; and livestock inventory. We discuss "land" as a separate primary input in the next section. Our discussion of the "capital stock" refers to the other three categories.

The capital stock grew rapidly between the mid-1950s and the mid-1960s (fig. 7). Much of this growth was attributable to land improvements, which grew by 60 percent. Land improvement during this period consisted mainly of improving pasture by establishing a clover crop and fertilizing it with superphosphate. Plant and equipment also showed a significant increase, reflecting the growth in mechanization. There also was a 20-percent increase in capital represented by the livestock herd (see table 1 and fig. 7).

Figure 7
Real nonland capital stock in Australian agriculture (1986-87 prices)



Powell (1974) points out that investment in various types of land improvements tends to use a combination of farm labor and purchased materials. This type of investment uses labor rather than replaces labor. Rapidly expanding farm mechanization between the mid-1950s and mid-1960s fostered land improvement. Mechanization freed scarce labor that could then be employed in improving the land.

Agriculture's capital stock continued to grow between the mid-1960s and the mid-1970s. Much of the increase was once again due to improvements to land. Livestock increased by 51 percent and plant capital grew by 17 percent.

Between the mid-1970s and mid-1980s, investment did not keep up with depreciation and the nonland capital stock diminished. Causes of this decline were a 21-percent fall in livestock capital and a 5-percent decline in the capital stock represented by land improvements. On the other hand, plant and machinery capital increased by 19 percent (see table 1).

Land

Land is defined here in an economic context. It is the soil and its associated natural fertility, water, and climatic conditions. Land also includes public infrastructure such as rural roads and irrigation schemes.

Total land area devoted to farming increased slightly between the mid-1950s and the mid-1960s. Since then, there has been little change (see table 1). However, the intensity of land use has increased greatly. The area of dryland sown to grains, pastures, or grasses, for example, increased 150 percent between the mid-1950s and the mid-1980s. The increase in improved pasture and other seeded area reflects a major increase in the capital stock of land improvements.

The amount of irrigated land also increased substantially in the early 1960s and 1970s as stages of the Snowy Mountains project, in the mountains south of Canberra, were finished. It was the largest irrigation and hydroelectrical project in Australian history. Elsewhere, new reservoirs were built on coastal waterways and older projects were expanded. By 1979, 1.6 million hectares (ha) were irrigated, whereas only 0.6 million ha were irrigated at the end of World War II (Davidson, 1981, p. 367).

The increase in agricultural output between the mid-1950s and mid-1970s, however, came mainly from the dryland areas. Davidson (1981) estimated that irrigated land accounted for only 13 percent of the substantial growth in output between 1947 and 1965.

The net effect of the growth of land area devoted to farming and the public investment in irrigation and other agricul-

ture-related infrastructure is shown in the index numbers for the land component of capital stock (see table 1). This index reveals a 38 percent increase in the land component of capital stock between the mid-1950s and the mid-1960s. Part of that expansion was due to the growth in irrigation facilities. The land component of capital stock expanded 32 percent between the mid-1960s and the mid-1970s, but less thereafter.

The index of land as a component of capital stock is not sensitive to possible long-term land degradation. Little is known about what has happened to the productive potential of land since the mid-1950s after allowance is made for the growth in the capital stock associated with land and improved farming methods. Per-hectare output has increased, but the expanded use of other inputs and improved efficiency may have masked the effect of land degradation. Degradation of the land resource implies a shift to the left in the agricultural supply curve.

Chartres (1987) states that there had been substantial land degradation before the 1950s and some since, but the data base for monitoring aggregate changes is very inadequate. Water and wind erosion are still problems in maintaining the productive capacity of the land. Irrigation infrastructure continues to deteriorate and depreciate in value. The water table in the Murray-Darling Basin (the largest river basin in Australia located in Victoria and New South Wales) continues to rise, accompanied by salinity problems. No aggregate measure of the effect of these events on land productivity is available, however. Burch, Graetz, and Noble (1987, p. 27) state that "... we understand the detail clearly but have no overview."

Labor

The agricultural labor force consists mainly of farm operators and their families, and hired workers. Both categories declined between the mid-1950s and the mid-1970s, but the number of farm operators and their families actually increased after that (see table 1).

The reduction in the labor force, at a time of rapid increase in output, indicates the effect of new technology and changes in relative prices of capital and labor. The opportunity cost of labor was high in the 1950s and 1960s because of the booming economy, but public and private capital investment in agriculture was subsidized. Subsidized capital encouraged investment in new, labor-saving technology. At the same time, there was a large increase in cash inputs that also resulted in more output per unit of primary input, especially per unit of labor.

Since the mid-1970s, however, farmers have faced rising interest rates while real wage rates have changed very little (see table 1). Martin and Savage (1988), who estimated farmers' net cost of capital since 1967, report that the ratio of the cost of capital to the cost of labor generally decreased before the mid-1970s and increased after that. This trend helps explain why the ratio of capital stock to labor in agriculture generally increased before the mid-1970s and decreased slightly afterward.

Cash Inputs

The cash category of production inputs consists of a long list of goods produced off the farm for use in agricultural production. It includes inputs such as fertilizer, fuel, repairs, and pesticides, but excludes cash cost payments associated with primary inputs such as wages, rent, and interest payments. Cash inputs, in the context of the supply curve in figure 6, are variable costs that increase as output is increased along the supply curve. Thus, increases in cash inputs represent a movement along a supply curve rather than a shift in the supply curve.

Use of cash inputs has expanded rapidly since the mid-1950s relative to labor and land inputs to agricultural production (see table 1). The traditional view of agriculture was that it created economic value by producing farm commodities from onfarm resources. Agriculture now is more accurately portrayed as a sector that adds value from purchased inputs as well as from onfarm resources. Consequently, it is becoming more misleading to measure agriculture's contribution to the economy's wealth and employment by examining only the production sector, as is done in this report. This approach leaves out the expanding input manufacturing sector and, as a result, tends to underestimate current agriculture's contribution.

Productivity Gains

The major source of the shift in the supply curve since the mid-1950s appears to result from gains in productivity per unit of input. That finding is supported by studies showing that although some inputs to agricultural production have increased since the 1950s and others have decreased, the total bundle of inputs has not increased.

Martin and Savage (1988) estimated the separate contribution to output of added inputs and productivity growth between 1965-66 and 1985-86. They show that inputs increased only marginally (0.3 percent a year). But the productivity of those inputs increased at a rate of 2.8 percent a year. This productivity rate was more than twice as high as the rate for the total economy. Dixon and McDonald (1988) estimated changes in output of agriculture, forestry, fishing, and hunting (along with other economic sectors) between 1971-72 and 1986-87. They estimated that the annual increase in output due to improved technical efficiency was about 1.5 percent, and the annual change due to "intensity of factor usage" was -0.3 percent.

Forces Underlying a Shift in the Supply Curve

We have highlighted how the supply curve for Australian agriculture shifted right since the mid-1950s, identifying the two main forces behind the shift as expanded capital stock and improved efficiency. The logical next question is,

"Why did it happen?" Schultz (1964) studied the development patterns of many countries and concluded that key ingredients for agricultural development were:

- Market- and Government-generated producer incentives;
- Growth of human capital; and
- The adoption of new technology.

These three ingredients also help to explain Australia's strong agricultural growth since the 1950s.

Incentives

Post-1950 agricultural output prices have declined relative to input prices and farming has been highly risky due to weather problems and volatile world markets. Yet, farming has proved profitable for many because improved productivity boosted profits. For many farms, the longrun average return rate on investment in agriculture has exceeded real Government bond interest rates. Kingma (1988) shows that farms with more than 200 sheep earned a return rate of 5.3 percent compared with a 3.1-percent Government bond interest rate between 1954 and 1988. Since the mid-1970s, however, the real rate of return for this same group of farms was only 1.3 percent compared with a 3.9-percent return on Government bonds.

Survey data reveal that during the 1950s, when output prices were relatively high, typical producers received net returns that were much higher than the earnings of the average wage and salary earner. Even during the 1960s, when costs were rising and farm commodity prices were falling, typical farm returns exceeded earnings of the typical nonfarm worker (Davidson, 1981, pp. 344-64). It was especially true for operators of larger farms, who could more efficiently use labor and the new farm machine technology.

Industry Assistance

Throughout the period examined in this report, agriculture received Government assistance that acted as an incentive to expand production and exports. The manufacturing sector also got assistance, which negatively affected agricultural production and exports. When one examines the effect of total Government assistance on agriculture, it is important to examine the relative levels of assistance (agriculture relative to manufacturing) as well as agriculture's absolute level of assistance.[3]

Government assistance to agriculture has a direct effect on incentives and profits. The level of assistance varies considerably by commodity, the highest being dairy, eggs, rice, and sugar, and the lowest being sheep, wool, beef, and grains. The overall level of agricultural assistance decreased over the period studied in this report.

Government assistance to agriculture has taken the form of subsidized input costs (fertilizer subsidy, low-interest loans) and subsidized or administered high commodity prices (dairy products, rice). Both forms of subsidy shift the supply curve (S_F, which is shown in fig. 1) to the right. The input subsidy lowers input costs and the product price subsidy encourages longer term investment due to higher profit expectations. As a result, the export supply curve (both ES_F and ES_P) also shifts to the right. This shift means that, at a given world price, Australia is able to export more agricultural products than if Government did not subsidize agriculture. Sugar policy is an interesting exception. Though the sugar industry is assisted by Government policy, sugar production is likely to be less than it would be if that policy were removed. An ABARE study, for example, estimates that, by removing various restrictions on production and milling, Australian sugar production in the mid-1980s could have expanded at least 30 percent and the average unit cost of transport, milling, and handling would be reduced (Borrell and Wong, 1986).

Government assistance to manufacturing industries (especially in the form of tariffs on agricultural input industries) increases agricultural production costs and shifts the production supply curve as well as the export supply curve to the left. Therefore, agriculture becomes less competitive. Government assistance to Australia's manufacturing industries also indirectly affects agriculture through the exchange rate. Assistance to manufacturing comes mainly in the form of tariff protection. Protection from foreign competition reduces imports, raises the value of the Australian dollar, and thus reduces the domestic prices of all exports. This effect could be shown in figure 1 as a downward shift in the export demand curve, ED.

The Industries Assistance Commission (IAC) has measured rates of assistance to agriculture since 1970-71, and rates of assistance to manufacturing since 1968-69. Their numbers show that, since 1970-71, aggregate agricultural assistance decreased somewhat more than manufacturing assistance. The effective rate of assistance to agriculture dropped from 30 percent in 1970-71 to 10 percent in 1974-75. After that, it varied between 8 percent and 17 percent. The effective rate of assistance to manufacturing was about 35 percent until 1972-73. It dropped to about 27 percent in 1973-74 and then gradually decreased to around 20 percent in the mid-1980s (Industries Assistance Commission, 1987; Martin, Waters, McPhee, and Jones, 1988). No measures of assistance were found for the 1950s and 1960s.

Research by Martin, Waters, McPhee, and Jones (1988) and the Centre for International Economics (1988) shows that the net effect of Government assistance to both economic sectors was to reduce agricultural production and exports—

[3]Subsidies to either sector can adversely affect the rest of the economy. Whether or not the country's resources are used more efficiently as a result of the subsidy depends on the levels of assistance to other sectors of the economy. Resources tend to be most efficiently used when either no sector is subsidized or all sectors receive the same level of subsidy.

to make agriculture less competitive—in the 1980s compared with what production and exports would have been without assistance to either sector. That conclusion likely would apply to the 1970s as well, because of the higher relative rate of assistance to manufacturing. Further research is needed to estimate the effect of assistance during the 1950s when Government support to agriculture was relatively high.

Human Capital

Schultz (1964) put considerable emphasis on the role of human capital in the development of agriculture. Human capital refers here to technical and management skills of the agricultural work force. Growth in Australian agricultural productivity came from increased human capital and new technology. The agricultural linkage between improved skills and new technology has been recognized by the Australian Government:

> Education and training are means of enhancing the capacity of farm labor to effectively manage and operate farm resources. For farmers, the increase in the quality of their labor is reflected in, for example, improved data management, organization of inputs and increased ability to recognize, comprehend and utilize new technology (Department of Primary Industries and Energy of the Australian Commonwealth Government, 1988, p. 7).

No adequate measure exists of either the level of human capital in Australian agriculture or the change over time. However, formal education, although only a part of human capital, is correlated with it and can thus be regarded as a proxy for human capital in total. As explained by the Department of Primary Industries and Energy (DPIE) of the Australian Commonwealth Government, "Outstanding farmers are not always those with much formal education but education is a quick and efficient way of gaining skills which can raise the overall performance of most farmers" (DPIE, 1988, p. 9).

There is little empirical evidence available about rural Australian education levels over the past three decades, but the statistical information that is available indicates that formal education levels in rural areas have been increasing steadily. For example, census data reveal that the proportion of rural workers holding a university degree increased from 0.4 percent in 1966 to 2.2 percent in 1976, and to 5.8 percent in 1986. Schapper (1982, p. 252) reported that there had been an "... upsurge in short courses in management for practicing farmers ..." and that "... in recent years there (had) been a reaching out by various agricultural educational facilities into farming communities."

Providing formal education opportunities is mainly the function of public agencies of the Commonwealth and States. In rural areas, this includes State agricultural extension, and primary, secondary, and tertiary education.

Although only circumstantial evidence is available, the expectation is that these forms of public education had a major effect on the rate of agricultural productivity increase since the mid 1950s.

New Technology

If new technology is to have an impact on agricultural productivity, it must be obtained, delivered to producers and integrated effectively into producers' farming methods. Most producers in the 1800s and early 1900s did all three steps themselves. Innovative producers made some major breakthroughs in adapting imported plants and animals to Australian conditions. They also became more efficient by the slow process of learning by doing, and by observing their more progressive neighbors. By the turn of the century, however, crop yields were falling, the livestock carrying capacity of the land was falling, and the country's natural resource base was being degraded. Agriculture had expanded by exploiting the resource base with little effort put into conserving it for future use (Donald, 1982).

Public support for agricultural research began to develop in the 1920s and 1930s. Research was carried out by the Commonwealth Scientific and Industrial Research Organization (CSIRO), research agencies in State departments responsible for agriculture, and universities. The Great Depression and World War II slowed the early growth of these institutions. These institutions made several research breakthroughs during their early years, but the Great Depression and the war delayed adoption of the discoveries.

Publicly funded research grew rapidly after the war. About 700 agricultural scientific personnel were employed by Commonwealth and State institutions in 1947, over half in State departments. By 1977, their number had grown to over 2,500, and the total budget had risen to $132 million. Over 50 percent of the total research budget was spent by State agencies, while only about 4 percent was spent by private agencies (Jarrett and Lindner, 1982).

During the late 1970s, however, total research funds for rural industry declined by about 25 percent in constant dollars from mid-decade levels (Williams, 1981). Comparable data for the 1980s are unavailable, but evidence suggests that the Commonwealth component of the agricultural research budget stayed about constant in real dollars (Industries Assistance Commission, 1983, 1987; Martin, Waters, McPhee, and Jones, 1988).

The rate of increase in the productivity of Australian agriculture since the mid 1950s has been impressive by historical standards and parallels events in other industrialized countries. For example, the productivity and output of technology based agriculture in Europe and North America were also rapidly increasing. These regions were also expanding their investment of funds in public and private agricultural research facilities.

Virtually all the plants and animals commercially grown in Australia came from other countries. Most had to be adapted to Australia's unique combination of soils, water, and climate. As a result, Australian agriculture is highly technology dependent. Farming systems had to be developed that enabled foreign varieties of plants and animals to thrive without degrading the environment. This adaptation process required science-based investigation.

Australia also benefited greatly from the agricultural technology of other countries. Examples are machinery, pesticides, and all the introduced stock of plants and animals. It is the policy of most nations to share their agricultural technology. And, since the 1960s, a network of international research agencies has helped raise the productivity of agriculture around the world, with emphasis on developing nations. But Australia, more than most countries, has had to rely on its own research to address its unique problems.

We have shown that there has been substantial Government support for agricultural research and that impressive gains in productivity have been achieved. But has the expenditure of public funds on agricultural research been cost effective? There is no comprehensive analysis, but studies in Australia and other countries show high rates of return on expenditures for specific, successful projects.

Jarrett and Lindner (1982, p. 104) summarized the available evidence in the late 1970s on the rate of return from agricultural research:

> ... all of the available evidence on returns to research suggests that there has been under-investment in rural research in Australia rather than the opposite, but all of the evidence also is subject to important qualifications. Therefore this important policy question must be considered to be unresolved, with a more definitive answer requiring more evidence of a less ambiguous nature.

The most comprehensive study of Australia's agricultural research is the 1980 study by the CSIRO Division of Entomology (Marsden, Martin, Parham, Ridsdill Smith, and Johnston, 1980). The study estimated the benefits from 13 of the division's research projects between 1960 and 1975 relative to the division's total budget. Results showed that the discounted expected benefits between 1960 and 2000 exceeded the division's discounted total costs between 1960 and 1975 by a factor of 4.4, using a discount rate of 5 percent. The authors consider this finding to be a lower bound estimate, since benefits from some of the division's projects were omitted and only direct benefits were estimated. These results suggest a high payoff from one significant component of agricultural research in Australia.

Marketing for Export

Additional costs and value are added to Australian agricultural export products after they leave the farm but before departing for a foreign shore. There are domestic costs for processing commodities into high-value products before being exported and for storage, handling, land transport, and getting commodities aboard ship. For example, grapes are transformed into wine before export. Changes in costs of these services are just as important as farm costs in determining competitiveness in international markets.

Since nearly all of Australia's agricultural exports are in the form of bulk commodities, only internal export marketing costs (domestic storage, handling, and transport) are discussed here. Other value-adding activities are not examined in this report, although they have been the subject of previous research (Trewin and Morris, 1987).

The link between marketing costs and competitiveness is illustrated in figure 1. The vertical gap between the export supply curve observed at Australia's border (ES_P) and the export supply curve observed at the farm gate (ES_F) represents domestic export marketing costs. Suppose the initial export supply curve were ES'_P in figure 1, and a new technology were introduced to reduce transport costs and shift the export supply curve to the right to ES_P. Agricultural producers would be the main beneficiaries of the reduced transport costs. They would export more (expanding output from Q_t to Q_d and expanding exports from Q_l to Q_x) and receive a higher price (increasing price from P_l to P_f). Lower marketing costs, in turn, would increase Australian agriculture's competitiveness in world markets.

There is some doubt as to the total cost of services added to agricultural exports between the farm gate and the ship. Recent estimates range from 15 percent of export unit value (calculated by the authors from ABARE data) to 20 percent (Freebairn, 1987). Either estimate suggests that there is potential for increased export competitiveness if these services can be performed at lower cost.

Export Marketing Costs

One can infer from rather limited data that the unit cost of services between the farm and the port has decreased markedly since the early 1950s. In real terms, marketing expenses per unit of total farm production have been on a downward trend (fig. 8). Since exports have been increasing as a proportion of production and marketing costs per unit of production have been falling, it is reasonable to assume that per-unit export marketing costs also have been declining. The implication is that since the mid-1950s significant gains in competitiveness have been achieved by lowering per-unit export marketing costs.

Land Transport and Port Costs

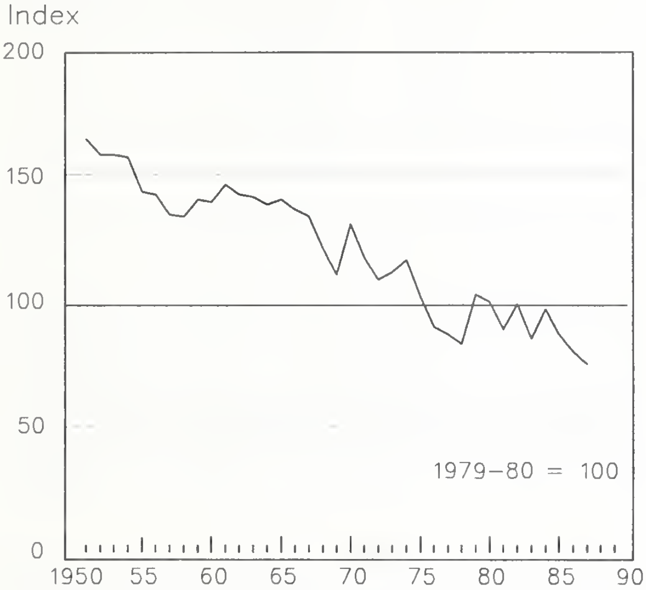
A high proportion of rural marketing costs are associated with transporting commodities. The major domestic methods of transporting agricultural products within Australia are truck and rail, followed by air and sea shipping (table 2). The proportion of total value of farm output absorbed by transport costs in 1980-81 ranged from 2

percent to 15 percent, depending on the commodity. In the aggregate, transport costs beyond the farm gate represented about 6 percent of product value.

Domestic transport of farm products has been highly regulated. Rail is the major method of transporting grain. Rail freight rates traditionally have been set on a cost-plus basis (called "value-of-service" basis in Australia) rather than on a competitive basis. Before the major roads were developed between World Wars I and II, the railways were "... free to develop a refined system of value-of-service rates. Subsequently, the States protected their railway systems against road competition so that the railway monopoly was prolonged" (Taplin, 1982, p. 152).

Figure 8

Marketing costs per unit of total Australian agricultural output, 1950-87 1/



1/ Marketing costs include freight, containers, commissions and other charges incurred in marketing. Index is calculated by dividing total marketing costs (Australian Bureau of Statistics, 1988a) by the index of total agricultural output (Australian Bureau of Agricultural and Resource Economics, 1987a).

Many of the legal restrictions on road haulage (trucking) have been removed or eased, but there still is a legacy of State intervention in the transport industry. This is particularly true of the transport of grains. The report by the Royal Commission into Grain Handling, Storage and Transport (1988a) found that deregulating bulk handling and rail monopolies could generate an average off-farm saving of $11 per ton. This saving represented about 5 percent of the then world price.

There also is room for significant reductions in the per-unit costs of port services. Waterfront activities are subject to policies that allow restrictive work practices. Unit costs are high due to overstaffing and industrial disputes. Moreover, fees are regulated. The National Farmers Federation claims that port inefficiencies and industrial problems add about 40 percent to farm export costs (Cribb, 1988). They estimate that "... the transfer of income from agricultural producers to the waterfront in direct overpayment of services and immediate associated financial costs is of the order of $130 million per year" (National Farmers Federation, 1988, p. 13).

The Royal Commission reported a "conservative" potential saving of $1.50 per ton of grain from revising restrictive practices in the shore-based distribution system (Royal Commission into Grain Handling, Storage and Transport, 1988b, p. 74). The commission also found that the most significant excess cost came from overstaffing on the

Table 2—Domestic transport costs in the Australian agricultural sector, 1980-81

Commodity	Costs of transport by— Truck	Rail	Air and sea	Total	Ratio of transport costs to total value of commodity output
	Million Australian dollars				*Percent*
Sheep	54	50	3	107	5
Cereal grains	94	180	10	284	12
Meat cattle	133	22	1	156	9
Milk cattle and pigs	59	1	0	60	4
Meat products	116	1	1	118	2
Milk products	46	7	0	53	2
Poultry	22	1	0	23	4
Other agriculture	188	48	16	252	10
Fruit and vegetable products	90	24	8	122	15
Total	802	334	39	1,175	6

Source: Derived from Shaw and Lever (1987).

waterfront. A recent report indicates that total excess costs of shore-based transport for all cargo, not simply for farm goods, could be on the order of $1 billion a year (Industries Assistance Commission, 1988, p. 53).

Domestic Demand

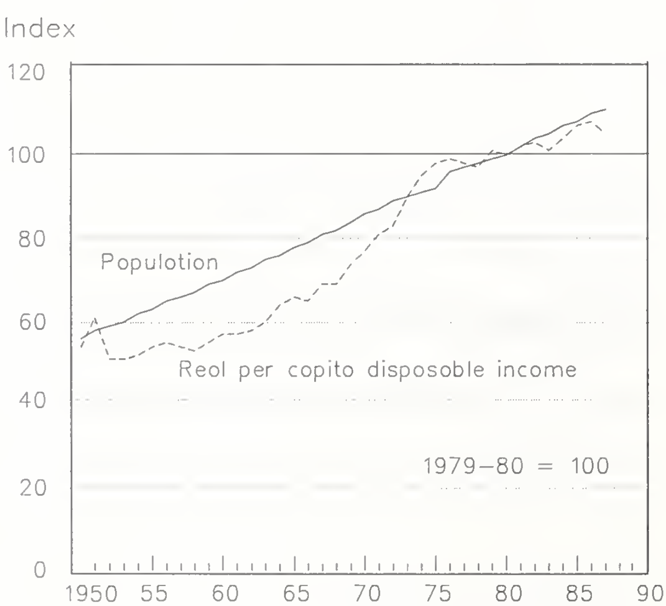
Domestic demand for agricultural commodities, as shown in figure 1, plays a role in shaping the export supply curve. Given no other change, a shift to the right in the domestic demand curve will shift the export supply curve to the left (see fig. 1). (For details of the domestic demand curve, see the appendix.)

The most important factors that cause shifts in the domestic demand curve are growth in population and changes in real income per person. The Australian population has increased at a steady rate over the last four decades (fig. 9). Income growth, especially in a wealthy country, is expected to have less effect on the demand for agricultural products than does population growth. Figure 9 shows rapid real growth in per capita income between the mid-1950s and the mid-1970s, but slower growth after that. These population and income data indicate a continuing shift to the right in the domestic demand curve for agricultural output.

Domestic demand increased between the 1930s and the early 1950s at about the same rate as agricultural production. As a result, exports did not expand. Since the mid-1950s, however, exports expanded because growth in production exceeded growth in domestic demand.

Figure 9

Australian population and per capita disposable income, 1950-87



Macroeconomic Forces and the Value of the Dollar

As we have shown, a change in the value of the Australian dollar relative to other currencies affects both commodity and input prices. A drop in the value of the Australian dollar, in general, is expected to eventually raise farm prices and to stimulate growth of the agricultural sector. The end result would be a shift to the right in the export supply curve, resulting in a more competitive agricultural sector.

Changes in exchange rates over time measure the aggregate effect of the performance of the Australian economy relative to other economies. Individual indicators of the economy's performance are the balance of trade, inflation, interest rates, and public budget deficits. Behind these indicators are Government fiscal and monetary policies. Thus, the net longer run effect of all these macroeconomic forces on agriculture's competitiveness can be summarized by the changing value of the Australian dollar.

The trade-weighted index value of the Australian dollar provides an aggregate measure of the dollar's value relative to the currencies of major trading partners. After years of stability of the Australian dollar, the index climbed in the mid-1970s as a result of economic policy decisions and the cumulative effects of a mining boom. Then a long decline began, which was only temporarily reversed by the second mining boom and associated export expansion in 1980-81.

Research by Gregory (1976) pointed out the linkage between the mining boom and agriculture's slowed growth. Exchange rates played an important role. Rapid growth of mineral exports caused the Australian dollar to appreciate, forcing down prices of agricultural commodities. Lower commodity prices would discourage growth. Later work by Stoeckel (1979) suggested that, had there not been a mining boom, the agricultural sector's growth rate in the early 1970s would have been substantially higher.

The long-term fall in the value of the Australian dollar after the mid-1970s resulted from a combination of slow economic growth overseas and even slower growth at home. The slowdown abroad caused a drop in demand for Australia's exports, especially primary commodities. The drop in export demand combined with structural rigidities, low productivity growth in the nonagricultural sectors, and high inflation at home to cause even lower growth in Australia's gross domestic product (Pagan, 1987).

Real prices of agricultural exports and production dropped between the mid-1970s and the mid-1980s (see table 1). If it had not been for the large drop in the value of the Australian dollar during the intervening years, those real prices would have fallen even more. The fall in the value of the dollar thus helped maintain the expectations of farm profit and prevented an even sharper drop in net investment in the agricultural sector between the mid-1970s and mid-1980s.

Forces Shifting the Export Supply Curve: A Summary

Australian agriculture has been able to maintain a highly competitive position in international markets and expand exports in the face of a longrun decline in world agricultural prices. This competitive performance is shown by the large shift right in the agricultural export supply curve since the 1950s (see fig. 5). The export supply curve shifted because of the shift right in the agricultural supply curve and the drop in marketing costs. These forces were somewhat offset by a continual increase in domestic demand (table 3).

The factors that appear to have shifted the *supply* curve for Australian agriculture are not quite the same before the mid-1970s as they were afterward. The earlier shift in supply is represented in figure 6 by the difference between the 1950s supply curve and the 1970s supply curve. "Fixed" capital stock of land and land improvements substantially increased during that period, while the agricultural labor force declined (see table 3). Productivity (output per unit of input) also increased. Much of the new "variable" inputs (new machinery, chemicals, livestock breeds) was associated with new technology. The changes in farming methods combined with new technology in the form of new investment and variable inputs to shift the supply curve right. These forces were only slightly offset by the decline in the labor force.

Between the mid-1970s and mid-1980s, there was a smaller increase in the land input, a slight decline in the nonland capital stock, and little change in labor. The shift right in the supply curve during those years apparently was due primarily to continued productivity improvements (see table 3).

Table 3—Forces shifting Australia's export supply curve between the mid-1950s and the mid-1980s

Source of shift	Hypothesized direction of shift in export supply curve in the period of— Mid-1950s to mid-1970s	Mid-1970s to mid-1980s
	Probable shift	
Supply factors:		
Land	R[1]	R[1]
Land improvements[2]	R	O
Plant and machinery[2]	R	R
Livestock[2]	R	L
Labor force	L	O
Technology	R	R
Land production potential	*	*
Marketing costs	R	R
Demand	L	L

[1] "R" represents an expected rightward shift in the export supply curve (making agriculture more competitive), "L" represents an expected leftward shift in the export supply curve (making agriculture less competitive), "O" represents no change, and "*" represents uncertain direction of change.

[2] See text for definitions of types of capital stock.

An important but unmeasured factor relating to the shift in the supply curve is the rate of degradation of agricultural land and water resources. The conventional wisdom is that some degradation occurred since the 1950s and, as a result, the aggregate production potential of the land declined. If true, this factor would shift the supply curve left.

Going into the 1950s, there was a backlog of new technology and a rapidly expanding public capacity to create and deliver it. To this potential was added the investment capital and incentives that came from highly profitable farming in the 1950s. Schultz's ingredients for growth (incentives, new technology, and human capital) were in place. The result was a rapid rate of increase in output, exports, and productivity. The new technology was embodied in the investment in land improvement, machinery, and livestock. Producers were also quickly increasing their use of cash inputs such as seed, pesticides, and fertilizer, which also incorporated new technology. And the new, more productive farming methods appear to have been less exploitative of the natural resource base than the old ones.

The public sector influenced the competitiveness of agriculture from the 1950s to the 1980s in many ways, mostly positive but some negative. Government assistance in the form of input subsidies and price supports provided additional incentives for producers to expand production. These subsidies, however, were gradually reduced. Government assistance to manufacturing, on the other hand, was a negative influence on agricultural growth.

Public investment in rural research, extension, and education appears to have yielded high returns. The high rate of increase in the productivity of resources employed in agriculture was based on new technology, much of which was discovered, adapted, and introduced to producers by Australian public institutions.

The shift right in the agricultural supply curve between the mid-1970s and the mid-1980s shows the importance to Australia of the growth in agriculture's production potential. Suppose that the production potential of Australia's agriculture had not changed between the mid-1970s and the mid-1980s but the rest of the world changed as observed. That is, suppose the 1980s supply curve in figure 1 were the same as the 1970s supply curve. With this no-growth supply scenario and the low commodity prices of the mid-1980s, production would have been down nearly 33 percent from what it actually was in the mid-1980s. Nearly 70 percent of agricultural output would have gone to meet domestic needs, and agricultural exports would have been down 60 percent from observed levels in the mid-1980s. Total Australian exports would have been reduced by about 20 percent, adding significantly to balance-of-payments problems and reducing the well-being of every Australian.

These are rough estimates, but they give an approximation of the magnitude of change that actually took place in agriculture between the mid-1970s and the mid-1980s. This export growth occurred with no increase in labor and with a decline in the capital stock. Export growth during these 10 years resulted primarily from continued increases in productivity.

Looking to the Future

Australian agriculture remained competitive in the past despite falling real prices of output. Competitiveness of Australian agriculture likely will be shaped by events and forces similar to those that shaped its past. Some forces, such as weather conditions at home and abroad and changes in the global trading environment, cannot be anticipated. There are other forces, however, that are either in place now or are quite predictable that will also have an influence. We focus on these as we look to the future.

We examine agriculture's future two ways. First, we assess conditions that are expected to prevail into the mid-1990s and make a simple projection. The projection is based primarily on the assumption that the major forces that shaped Australian agriculture in the postwar years (from the perspective of 1988) will be chiefly responsible for shaping agriculture through the mid-1990s. The argument underlying this assumption is that these forces are somewhat slow to change in a relatively short timeframe of 10 years. Second, we discuss some of the more predictable policy issues and economic forces that will shape agriculture beyond the mid-1990s.

A Simple Projection

One way to look at the competitiveness of agriculture in the future is simply to project the past. Between the mid-1950s and the mid-1980s, the supply curve shown in figure 5 shifted to the right at the annual rate of 4.1 percent. We assume a more modest rate of 3.5 percent for the 10 years between the mid-1980s and the mid-1990s. Further, the domestic demand curve is assumed to shift to the right at the projected annual population growth rate of 1.3 percent. Finally, we assume that there is no change in the real cost of marketing and handling services per unit of agricultural exports.[4] The projected export supply curve (curve labeled "1990s" as shown in figure 5) is obtained by calculating the quantity difference between the projected supply curve ("1990s" curve as shown in figure 6) and the projected demand curve (see the appendix).

After estimating supply, demand, and export supply curves for the mid-1990s, we make projections of annual production and exports that depend on assumptions about commodity prices. First, we assume that real prices of agricultural exports would return to the low average level observed in the mid-1980s. At these assumed prices, production in the mid-1990s would increase 41 percent and exports would increase 65 percent over their mid-1980s levels. However, real export prices have traditionally shown a long-term downward trend. A second, lower bound price scenario would be to assume that real export prices dropped an additional 25 percent by the mid-1990s. The projected supply and demand curves indicate that production would still increase 15 percent and that exports would rise 8 percent. At this low price level, the increase in production would barely keep ahead of growth in domestic demand. If a smaller growth in potential supply (that is, a smaller shift to the right in the supply curve) had been assumed, both of the above sets of projections would be reduced.

This simple projection presents a picture of continued expansion of Australia's agricultural exports and continued growth in competitiveness stemming from expanded export supply. It implies a significant increase in resources invested in agriculture and/or a significant increase in resource productivity. This projection is not entirely unrealistic, because it appears that there will be more positive than negative forces affecting growth in production over the next few years. On the positive side, higher commodity prices, at least for a few years in the late 1980s, should lead to improved expectations and an increased rate of private investment in agriculture. Moreover, there are no strong indications that the past impressive rate of improvement in technical and economic efficiency will drop off in the next few years.

An alternative view of the future, however, is that the land frontiers have been reached and the easy efficiency gains have been made, which could make further efficiency gains more difficult. Under these conditions, agricultural production would not keep up with the expansion of domestic needs and agricultural exports would decline. It is not possible, with existing information, to rule out this possibility. This issue is taken up below.

Forces Shaping Agriculture's Longrun Future

This report identifies the major positive domestic forces that shifted the agricultural export supply curve in the past: production incentives, growth in human capital, and adoption of new technology. Improved marketing efficiency and generally positive macroeconomic forces were also important.

Negative forces were some degradation of the natural resources base and Government assistance to the manufacturing sector. Work practices that have inhibited productivity growth in transporting and handling commodities were also detrimental to agricultural competitiveness.

Agriculture's longer run future will continue to be shaped by these forces. One can make several observations about the future of those forces that are not too speculative.

[4]This assumption is strong, given the changes already underway in reducing grain handling costs. Thus, the projections of export supply are conservative.

First, the long downward trend in farm commodity prices relative to input costs is likely to continue. This observation is derived from the expectation that the production potential of the world's farmers will continue to expand faster than will global demand. Commodity prices likely will be highly unstable around that downward trend.

Second, domestic demand for Australian agricultural products will continue to grow. The growth rate in demand will depend on how fast population and real personal income grow.

Third, real wages are expected to increase as the economy grows. Higher real wages mean higher agricultural labor costs. Also, as personal incomes increase in nonfarm sectors, farm operators will expect to keep pace. This chain of events will continue the pressure toward fewer and larger farms.

These three forces are continuations of past long-term trends. They had a negative influence on growth in agricultural exports in the past, and that pattern is expected to continue. If they were not offset by other forces, these three forces would shift the future export supply curve to the left, reducing agriculture's competitiveness in international markets.

Four additional forces that could affect the export supply curve and the competitiveness of Australian agriculture are easy to identify but difficult to project. All are linked to Government policy. They include Government assistance to agriculture and to other industries; regulation of marketing; public investment in research, extension, and education; and regulation of land and water use.

Government assistance to both agriculture and manufacturing has diminished in the past 20 years. These trends could continue, but recent research shows that they would little affect export volume. Totally removing assistance to agriculture would reduce agriculture's real net returns by about 10-12 percent. The immediate effect would be a drop in exports by less than 5 percent (Martin, Waters, McPhee, and Jones, 1988; Centre for International Economics, 1988). The longer run effect would be greater due to reduced profit expectations and reduced investment. If assistance to both sectors were removed, net returns to agriculture would increase 6-8 percent, but there would be only a small shortrun increase in agricultural export volume. In the longer run, there likely would be some further expansion of exports.

As figure 1 showed, a drop in the cost of storing, transporting, and handling commodities for export reduces the gap between ES_p and ES_F. The net result is a shift to the right in the export supply curve, ES_p. Recent studies have shown that Commonwealth and State regulation of these marketing activities could be modified to reduce their costs (Trewin and Morris, 1987; Royal Commission into Grain Handling, Storage and Transport, 1988a, b). Political pressure could build to reform these marketing services and reduce their cost. Though significant, the total effect on the export supply curve would not be very large. For example, these marketing services add about 15-20 percent to the cost of the exported commodity. Thus, even a highly unlikely 25-percent reduction in marketing costs would reduce the cost of the exported good by only 4-5 percent. Lower marketing costs resulting from modified regulations would help expand exports, but the effect over the long run might be small compared with export gains from publicly backed research/education and Government policymaking regarding land and water use.

Rural research, extension services, and education have been crucial to the impressive growth in productivity of agriculture in Australia as well as in other major exporting countries. These publicly supported services have helped Australian agriculture to be profitable for investment in the face of a long-term fall in real commodity prices. The continuing competitiveness of Australian agriculture appears to depend on these productivity-increasing services.

Agriculture's longrun future is tied to the land. Future production potential of the land, and future competitiveness, are reduced to the extent that natural resources have been degraded to increase current output. Land degradation problems in the future, as in the past, will be addressed by improving farming methods and modifying land use policy. Both rely on sound research. Public support for research will continue to be needed to provide vital information used to develop a resource policy benefiting Australian agriculture's longrun economic health and competitiveness.

Implications for Australian Policy and Economic Research

Australia has abundant natural resources that give it a comparative advantage in producing and exporting agricultural commodities. This resource base gives Australia a natural competitive edge in world commodity markets. The production and export potential of Australia's agricultural resources were greatly expanded after the early 1950s, mainly due to political and institutional environments that encouraged new investment and increased productivity. Imported technology also contributed to the expanded farm export potential.

Australian Policy

Agriculture, because of its comparative advantage, will continue to contribute importantly to Australia's export earnings. Whether the earnings grow or diminish will depend on events in world markets and at home. Events at home can have a major effect on the future competitiveness of agriculture.

More than most industries, agriculture's future depends on Government action. Key policy decisions include:

- The level of assistance to agriculture and manufacturing;

- Cost-reducing measures for getting commodities from the farm to foreign buyers;

- Support for rural research, extension, and education; and

- Control of the use and misuse of land and water.

Economists have analyzed the first two issues. The gains and losses to agriculture and other industries resulting from alternative policy decisions are generally understood. Research shows that agricultural competitiveness will be influenced by those decisions.

The last two issues, however, could have the most important longrun effect on agriculture. Yet little is known about the relationship of either of them to agricultural production and exports. Policy decisions about the type and amount of public funding; the control of research, extension, education, and conservation; and the use of water resources will be made whether or not there is an adequate information base. However, those decisions are more likely to be in the longrun public interest if the research community provides appropriate technical and economic information.

An Economic Research Agenda

Reviewing the literature and writing this report revealed gaps in the economic analysis of Australian agriculture. Significant growth in agriculture's past production and export potential can be observed. Economic theory and research in many countries suggest which factors were the main contributors to or main detractors from that growth. Very little, though, can be said about how much each factor contributed to that growth, yet that information is vital to informed public and private policy decisions.

Several shifts in emphasis are suggested for Australia's economic research agenda to address issues raised in this report. They are to put more emphasis on the longer run and on natural resources. We recommend four general topics that need to be researched in order for Australia to better address issues of longrun agricultural competitiveness. Each topic will be highly challenging to the economic research community.

First, estimate the longrun supply function and price elasticity of supply for Australian agriculture in the aggregate. Results from this research would show how agricultural production responds to longrun changes in prices of inputs and output, how freely capital and labor would move into or out of agriculture, and how public policy would affect agriculture in the long run.

Second, estimate the net benefits from various forms of publicly and privately funded agricultural research. Circumstantial evidence suggests that the net benefits have been very high. If so, then a substantial investment is justified. Since most agricultural research in Australia is publicly funded, decisionmakers need to have evidence of the rate of return on research expenditures in order to make future funding decisions.

Third, estimate the net return to public investment on human capital development in the agricultural sector. How much has this investment contributed to agricultural productivity growth? What would be the payoff from additional investment?

Fourth, assess if or how much natural resources are being degraded by farming. What are the costs and benefits of controlling future degradation? What are the costs and benefits of repairing the damage caused by past degradation? One part of this research topic would be to develop an updated inventory of the natural resources used for farming that will measure change in the aggregate productive potential of these resources (Australian Environmental Council, 1988).

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Appendix: Supply, Demand, and Export Supply Curves

The derivations of Australia's domestic agricultural supply and demand curves, and the export supply curves, are described here. We discuss concepts, review the literature on recent estimates of elasticities, and present the estimates used in this report.

Domestic Agricultural Supply: Assumptions

To construct the supply curves for agriculture in figure 6, one has to determine (a) an appropriate functional form, (b) the economic and calendar period of adjustment the curves represent, (c) the location of the curves, and (d) the slope or price elasticity of the curves. Much doubt about agriculture's supply response to product price changes is expressed in the economic literature. Empirical evidence does not conclusively support any one of the conventional functional forms. We used the constant elasticity functional form for this project because of its simplicity. It adequately meets the project needs while requiring that only two parameters be specified: a constant and a price elasticity of supply. The latter is obtained from other studies and the former is obtained by solving a simple equation for a specified price and quantity.

The supply curves used in this report represent 5-year adjustment periods. Points along the curves represent the quantities that would be produced (and the implied resource adjustment) in response to specified prices that were expected to prevail throughout the 5-year period. Five years is an intermediate economic time horizon in which some farm resources are fixed and the remainder is optimally allocated.

The locations of four supply curves were determined, with the curves representing equivalent 5-year adjustment periods in each of the four decades being considered. We assumed that average production over a 5-year period was an accurate estimate of optimal output for the average farm prices that prevailed during that period. For example, a point representing average annual production and average annual prices from 1952-53 to 1956-57 was assumed to lie on the intermediate run supply curve for that period. A 5-year average was used to minimize year-to-year variation in prices and output from their expected levels. Similar computations were made for 1962-63 to 1966-67, 1972-73 to 1976-77, and 1982-83 to 1986-87. These periods are shown from here on as 1953-57, 1963-67, 1973-77, and 1983-87.

Estimates of the price elasticity of supply (referred to here as supply elasticity) were needed to construct a constant elasticity supply curve for each of the four decades. For simplicity, the supply elasticities for the four curves were assumed to be the same. Pandey, Piggott, and MacAulay (1982), however, suggest that the supply elasticity has increased over time.

Elasticity of Supply

The following formula provides a conceptual base for discussing the elasticity of supply

$$E = (S \times V) / F \qquad (1)$$

where E is the elasticity of supply; S is the elasticity of substitution among primary factor inputs; V is the share of the variable primary factor inputs in total primary factor inputs (total value added); and F is the share of the fixed primary factor inputs in total industry costs.

This formula may be used to approximate the supply elasticity by estimating the values of the variables. For a discussion of the formula, see Higgs (1986) or Martin, Waters, McPhee, and Jones (1988, p. 121). This formula specifically applies to the two-step production process employed in the ORANI model (Dixon and McDonald, 1988).

The supply curve in our study is assumed to represent a 5-year adjustment period. Thus S, F, V, and E need to be consistent with that period. Consider the following classification of approximate factor inputs for the period 1983-87 (in billions of 1986-87 Australian dollars):

	Billion Australian dollars
Fixed primary inputs:	
Land, land improvements, and structures	3.4
Family labor	2.5
Subtotal	5.9
Variable primary inputs:	
Hired labor	1.5
Machinery and livestock	1.4
Subtotal	2.9
Cash inputs	8.6
Total of all costs and value of agricultural output	17.4

Using these data, V equals 0.33 and F equals 0.34. S, the elasticity of substitution, is assumed to be 1. The assigned value of S falls between the shortrun value of 0.5 and the longrun value of 1.28 used in the ORANI model (Higgs, 1986). The computed value of E, the supply elasticity, is 0.97.

This estimate of supply elasticity is subject to several qualifications. First, the above resource categories are somewhat arbitrary, because, in reality, some portion of all primary inputs will vary over a 5-year time horizon. Second, the estimates could be subject to substantial error, because accurate measures of the inputs are not available. Third, the value of S is also somewhat arbitrary. Fourth, returns to fixed primary inputs during the 1983-87 period were less than their longrun opportunity costs (Kingma, 1988). This difference implies that the computed value of E overstates the supply elasticity that would hold in equilibrium. Fifth, and possibly most important, the estimate assumes that the land input is fixed and homogeneous. The quantity available to agriculture may be fixed, but land definitely is not homogeneous. Land of marginal quality will come into or out of production as product price changes, but high-quality land will remain in production. The above classification of land as a fixed primary factor of production misrepresents the land input and gives a downward bias to the elasticity estimate.

It is notable that as purchased inputs increase as a percentage of total factors of production, supply elasticity increases. There is evidence that this happened over the last 30 years (Pandey, Piggott, and MacAulay, 1982), bringing into question the assumption that supply elasticity has remained constant.

No input is fixed in the real world. Some marginal adjustments continue to be made in the number of farm operators, the investment in capital structures, and the area farmed. Thus, it is difficult to clearly differentiate between forces shifting the supply curve and movements along the curve. The approach we used is to conform the limited data to economic theory.

The only direct estimate of the supply elasticity for total agriculture is that by Pandey, Piggott, and MacAulay (1982, p. 215). They conclude that "... the long run elasticity is estimated to be about 0.6 or close to 1.0, depending on assumptions made about the elasticity of demand for capital items with respect to output price." Their data cover the years 1950-51 to 1975-76.

Other Estimates of Supply Elasticity

We also obtained estimates of aggregate agricultural supply elasticity from three quantitative models: the ORANI Model of the IMPACT Research Centre at the University of Melbourne, the Econometric Model of Australian Broadacre Agriculture, and the Regional Programming Model. The last two are ABARE models. None provided a direct estimate for total agriculture, but approximations could be obtained from published results of studies using the models.

ORANI. ORANI is the name of a general equilibrium model of the Australian economy that is described in Dixon and McDonald (1988). Equation (1), which is the equation for E, above, is used in ORANI. Shortrun (2-year) estimates of agriculture's aggregate supply elasticity are implied by the input coefficients and assumptions about which primary inputs to each agricultural industry are fixed and which are variable. In a version of ORANI reported in Higgs (1986), all agricultural labor is assumed to be variable. The supply elasticity falls between 0.9 and 1.0. This range is a partial equilibrium estimate based on the assumption that the rest of the economy does not adjust. A general equilibrium estimate of agricultural supply response (that is, allowing the whole economy to optimally adjust to changes in agricultural prices) is approximately 0.5 (estimated from Higgs, 1986, pp. 58-59). The partial equilibrium estimate is appropriate for our study.

In another version of ORANI, the only variable primary input factor is assumed to be hired labor (Martin, Waters, McPhee, and Jones, 1988, pp. 121-29). Thus, a smaller share of primary factors is assumed to be variable than in the Higgs study. This difference leads to a smaller estimate of aggregate supply elasticity (less than 0.2) than in the Higgs study.

Econometric Model of Australian Broadacre Agriculture (EMABA). EMABA is a dynamic econometric model of extensive agriculture. Extensive agriculture, called "broadacre" agriculture in Australia, is beef, sheep, and dryland grain farming. The aggregate supply elasticity obtained using EMABA is 0.22 after 5 years of adjustment and it is 0.3 after full adjustment (Martin and Shaw, 1986). Total land area and farm operator labor are assumed to be fixed. Land may be improved if profitable. The supply elasticity of improved land is 0.32 for changes in the profitability of improved land.

Regional Programming Model (RPM). The RPM is a static mathematical programming model of extensive agriculture that represents about 60 percent of Australia's agricultural production (Hall, Fraser, and Purtill, 1988). The RPM has an aggregate medium-term (5-year) supply elasticity of 0.69 and a long-term estimate of 0.83. The long-term estimate is constrained only by the fixed area of land and given technical coefficients. The medium-term elasticity is further constrained by an upper limit on the expansion of ewes and beef cows.

Summary. The above information indicates that there is no consensus on the elasticity of aggregate agricultural supply. The difference between 0.2 and 1.0 is very large when one wishes to address the question of longer run production adjustment to changes in real output prices.

After examining the estimates and assumptions of these studies, we determined that the supply elasticity that best represents total agriculture in the medium term (5-year adjustment) is 0.7. An alternative value of 0.3 was also examined to test the sensitivity of the major results.

Agricultural Supply Curves

The agricultural supply curves in figure 5 are of the form

$$Q_t = C * T_t * P^e \quad (2)$$

where t values from 5 to 8 represent the decade of the parameter (that is, 5 = 1953-57, 6 = 1963-67, 7 = 1973-77, and 8 = 1983-87); Q is an index of quantity produced (1983-87 average = 100); C is a constant (C = 3.98); T is a shifter (T_8 = 1.0); P is an index of real farm-gate prices (1983-87 average = 100); and e is the elasticity of supply (e is assumed to be 0.7).

The value of C is computed such that the supply curve goes through point A in 1983-87 (figure 6) with T_8 assigned the value 1. Point A represents the observed average quantity index (Q = 100) and observed average price index (P = 100). To obtain supply curves for the previous decades, values of T_t are calculated to allow the supply curves representing those decades to go through their observed quantity/price points. The calculated T values are T_5 = 0.30, T_6 = 0.49, and T_7 = 0.70.

The rate of change over time in T represents the annual rate of quantity shift in the supply curve. For example, the equation $T_8 = T_5 \times (1 + r)^{30}$ can be used to calculate r, the annual rate of change of T over the 30 years between the 1950s supply curve and the 1980s supply curve. With T_5 = 0.30 and T_8 = 1.0, the calculated value of r is 0.041. This statistic means that the supply curve shifted to the right at an average rate of 4.1 percent a year over the 30 years.

Note that if the supply curves were less elastic, the shift would be reduced. For example, if a supply elasticity of 0.3 had been assumed for all supply curves, the recalculated T-values would show an annual shift of only 3.2 percent.

The Domestic Demand Curve

Both a domestic demand curve and a supply curve are needed in order to compute an export supply curve. A demand curve is derived for 1983-87, but none are derived for the earlier decades because additional assumptions would have to be made about earlier changes in demand. For the purposes of this report, simple linear export supply curves are directly derived for the earlier decades.

The domestic agricultural demand curve for 1983-87 is

$$D_8 = 187.1 \times U_8 \times P^{-0.3} \quad (3)$$

where D_8 is an index of quantity consumed (the average quantity produced during the 5-year period is equal to 100 and the average quantity consumed is equal to 47), U_8 is a shifter set equal to 1, and P is an index of farm-gate price, as defined for the supply curve. The constant, 187.1, is computed such that the curve intersects the actual average quantity consumed during the 5-year period.

Export Supply Curves

The equation for the 1983-87 export supply curve is $X_8 = Q_8 - D_8$ (adjusted for change in quantity indexes), or

$$X_8 = ((3.98 \times T_8 \times P^{0.7}) - (187.1 \times U_8 \times P^{-0.3})) \times 1.89 \quad (4)$$

where X_8 is the index of quantity exported (actual 5-year average for 1983-87 = 100), and T_8, U_8, and P are as defined above. The constant, 1.89, converts the quantity indexes such that average exports in 1983-87 equal 100. Note that the export supply equation shows the quantity exported as the difference between quantity supplied and quantity demanded at a given farm-gate price. The export supply curve is not a constant elasticity function. At P = X = 100 (in 1983-87) the elasticity of export supply is 1.6. For the sake of simplicity and due to the lack of an estimate of domestic demand, we used linear curves to represent export supply curves for the 1950s, 1960s, and 1970s. The value of 1.6 was used as an approximation of the export supply elasticities at the observed price/quantity point (point A) on each of the past export supply curves in figure 5. It is likely, however, that the export supply curve has become less elastic over time, because exports have increased as a share of agricultural production.

Projections

The projection of the supply, demand, and export supply curves to 1993-97 was obtained by inserting projected values of T_9 and U_9 into equations (2), (3), and (4). The assumed value of T_9 is 1.41, representing a shift right in the supply function of 3.5 percent a year over the 10 years between 1983-87 to 1993-97, compared with 4.1 percent over the previous 30 years. A growth rate of 3.5 percent is comparable with the ABARE's medium-term outlook to 1992-93 (ABARE, 1987b). The projected value of U_9 is 1.14, representing an annual domestic population growth rate of 1.3 percent beyond 1983-87. The projected equations are:

Supply: $$Q_9 = 5.61 \times P^{0.7} \quad (5)$$

Demand: $$D_9 = 213.3 \times P^{-0.3} \quad (6)$$

Export supply: $$X_9 = ((5.61 \times P^{0.7}) - (213.3 \times P^{-0.3})) \times 1.89 \quad (7)$$

Equation (5) is plotted as the 1990s curve in figure 6. Equation (7) is plotted as the 1990s curve in figure 5.

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